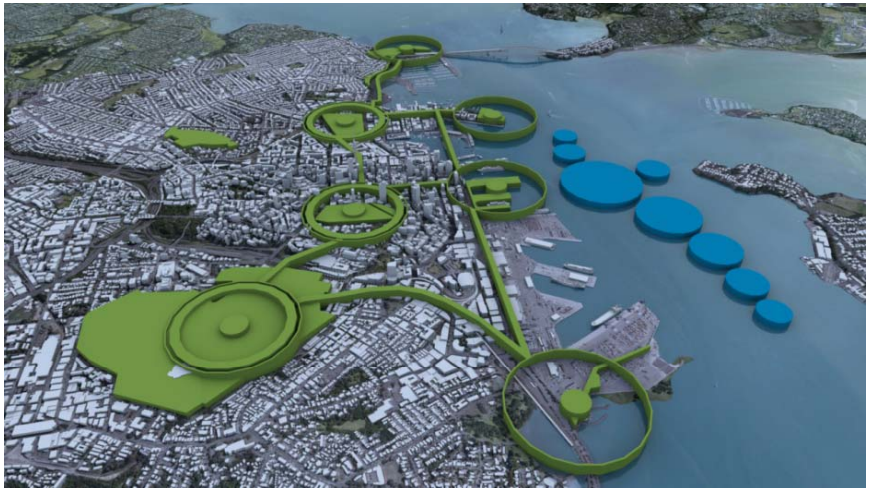
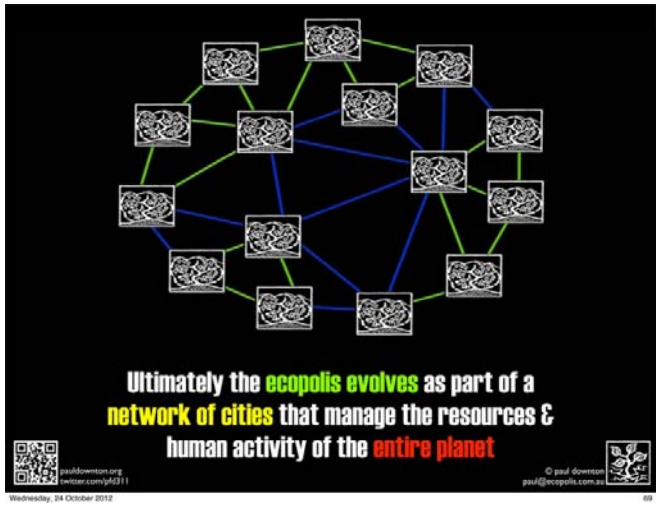
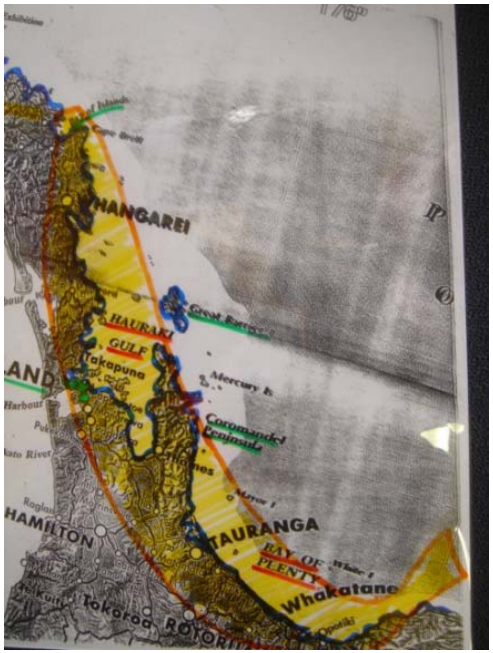
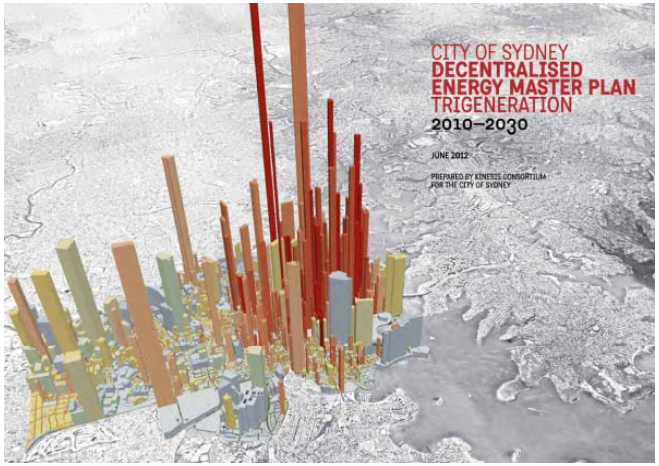
Future Proof Seminars 2012



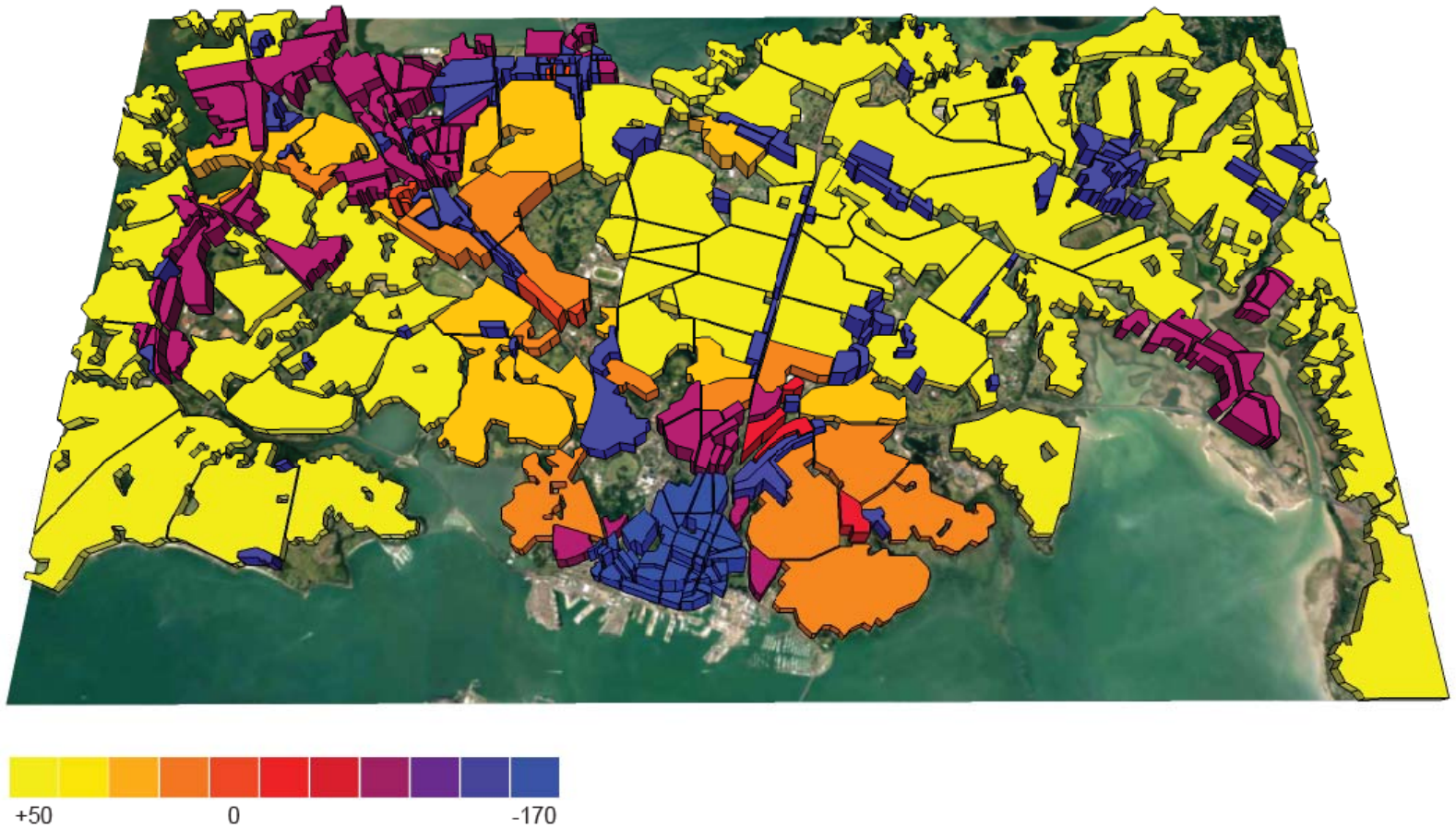






Compact Cities:
shaping the city with emerging technologies

Hugh Byrd



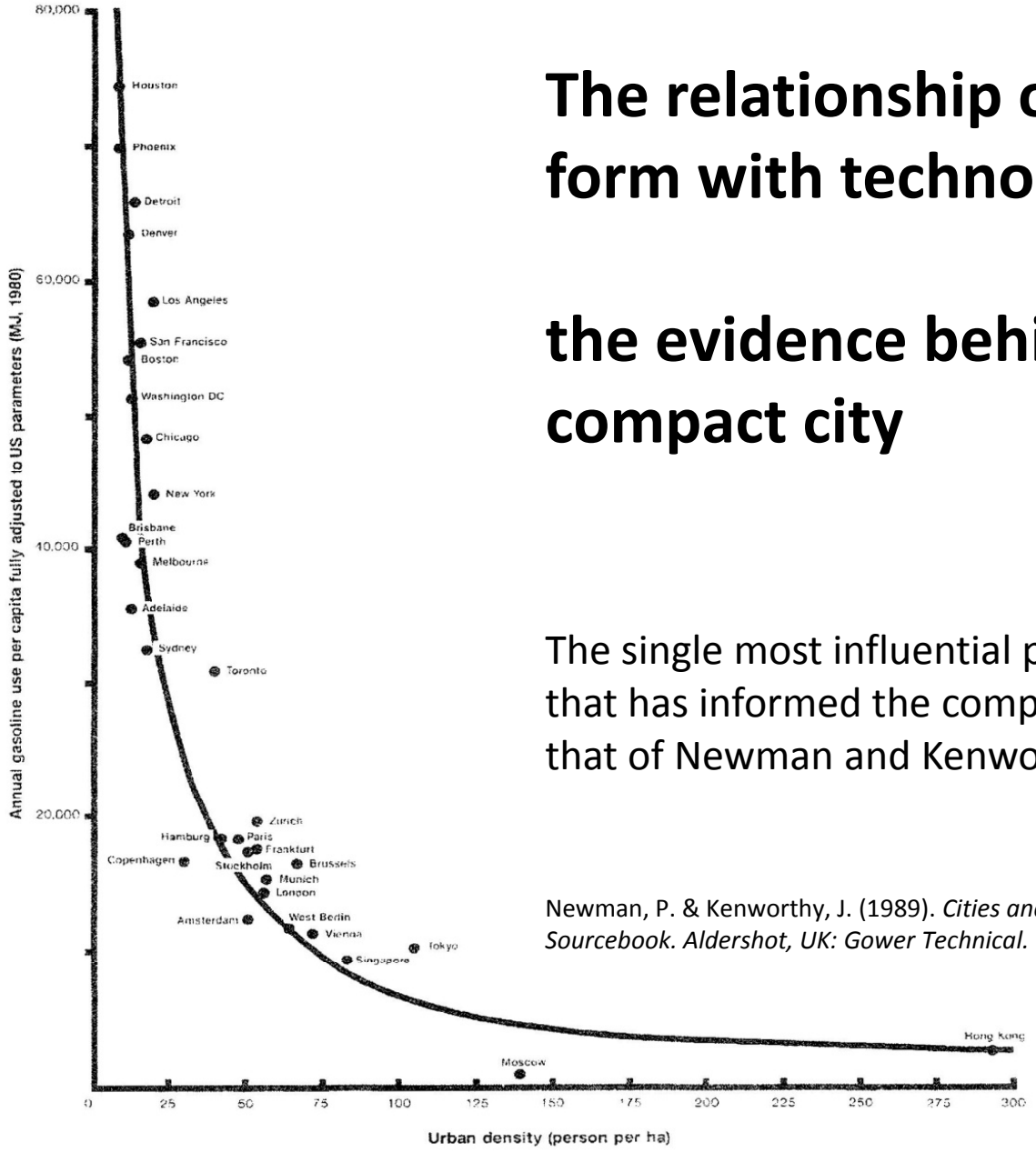
Acknowledgements: Anna Ho, Basil Sharp, Nirmal Kumar Nair
Funding from The University of Auckland, ‘Transforming Cities’

The relationship of urban form with technology:

the evidence behind the compact city

The single most influential piece of research that has informed the compact city debate is that of Newman and Kenworthy

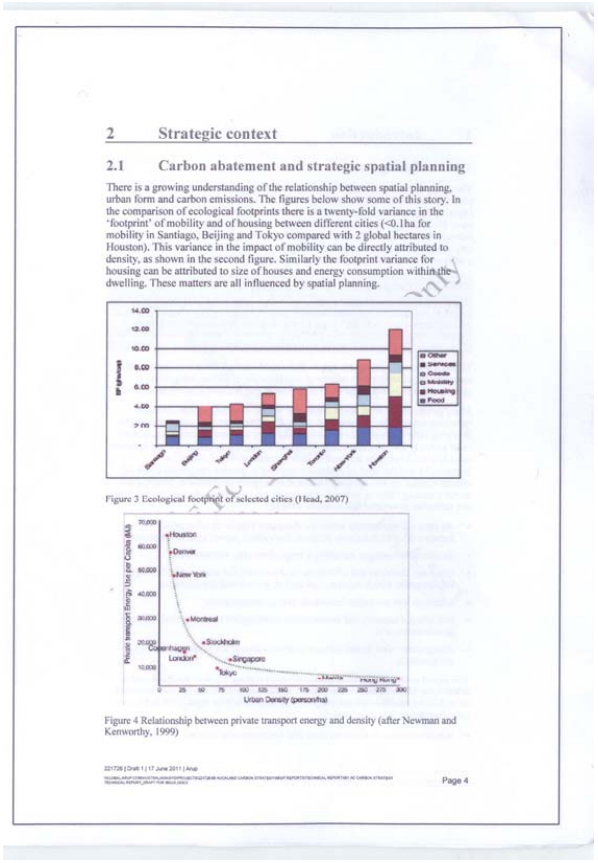
Newman, P. & Kenworthy, J. (1989). *Cities and Automobile Dependence: A Sourcebook. Aldershot, UK: Gower Technical.*



- Gasoline use per capita versus urban density adjusted to US income, vehicle efficiencies and gasoline prices
(P. Newman & Kenworthy, 1989)

The Impact of Newman & Kenworthy's research

ARUP (2011) Auckland Council Carbon Strategy, Technical Report



2 Strategic context

2.1 Carbon abatement and strategic spatial planning

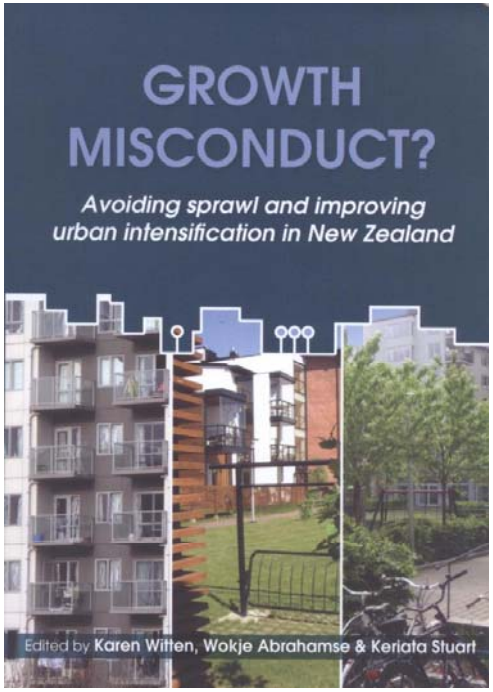
There is a growing understanding of the relationship between spatial planning, urban form and carbon emissions. The figures below show some of this story. In the comparison of ecological footprints there is a twenty-fold variance in the 'footprint' of mobility and of housing between different cities (<0.1ha for mobility in Santiago, Beijing and Tokyo compared with 2 global hectares in Houston). This variance in the impact of mobility can be directly attributed to density, as shown in the second figure. Similarly the footprint variance for housing can be attributed to size of houses and energy consumption within the dwelling. These matters are all influenced by spatial planning.

Figure 3 Ecological footprint of selected cities (Head, 2007)

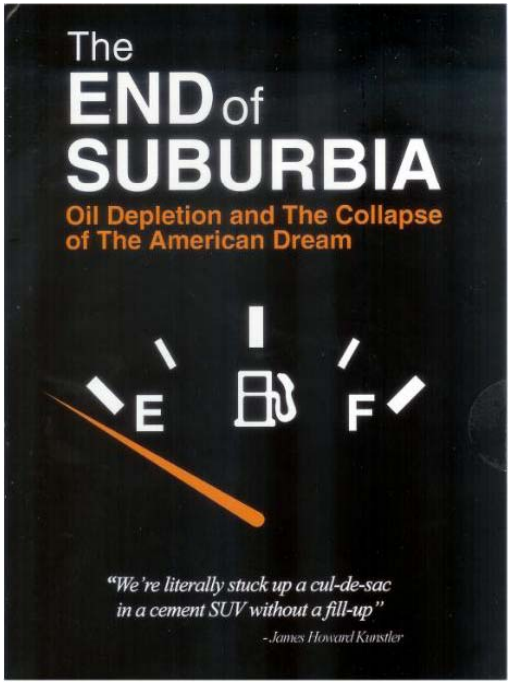
Figure 4 Relationship between private transport energy and density (after Newman and Kenworthy, 1999)

Page 4

Karen Witten; Wokje Abrahamse; Keriata Stuart (eds) (2011)
Growth Misconduct? Avoiding sprawl & improving urban intensification in New Zealand. : Steele Roberts, 2011.



Greene, G (2004)The End of Suburbia: Oil Depletion and the Collapse of The American Dream



Major Criticisms of Newman and Kenworthy

1. **Gross urban density is a poor measure of a city's dispersion**.

   Arza Churchman (1999) Disentangling the Concept of Density *Journal of Planning Literature 1999 13: 389*

2. **Car ownership, household income, fuel prices and employment density were not considered.**

Orit Mindali, Adi Raveh, Ilan Salomon. (2004) Urban density and energy consumption: a new look at old statistics. *Transportation Research Part A 38 (2004) 143–162*

My Research Questions:

Newman & Kenworthy's research is based on the use of fossil fuels for transport:

1. What are the likely alternatives to fossil fuels and the internal combustion engine for urban transport in the future?

2. What will be the impact of these on urban form?

3. Should urban policy be based on short- term oil or long-term renewable energy?

Emerging Technologies

- Photovoltaics (PVs)
- Electric vehicles (EVs)
- Smart grid, smart meters, urban EV charging

New Ford Focus to come with solar panels (for your home)

Buy the Focus Electric, and a 2.5-kilowatt rooftop solar panel can be part of the deal. This car charges on zero-emission solar power, which is much cleaner than the dirty grid.

Thu, Aug 11 2011 at 11:06 AM EST Like 46 2

VIVA LAS VEGAS: Ford unveils the Focus Electric. (Photo: Jim Motavalli)

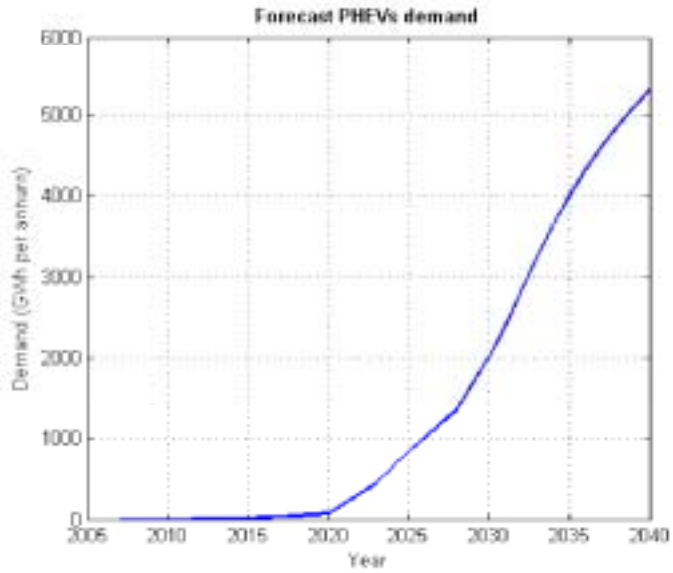
It's a cliché to start a story about auto-based solar with "here comes the sun," but, well, here comes the sun. Ford is teaming up with SunPower on a pretty cool idea — since electric cars aren't all that green if they charge off a dirty coal grid, the company is offering its Focus EV customers a chance to install a 2.5-kilowatt rooftop solar array that can produce 3,000 kilowatt hours of electricity annually, about what you'd need to drive 1,000 miles a month.

EECA

New guidelines to help bring electric vehicles to the market

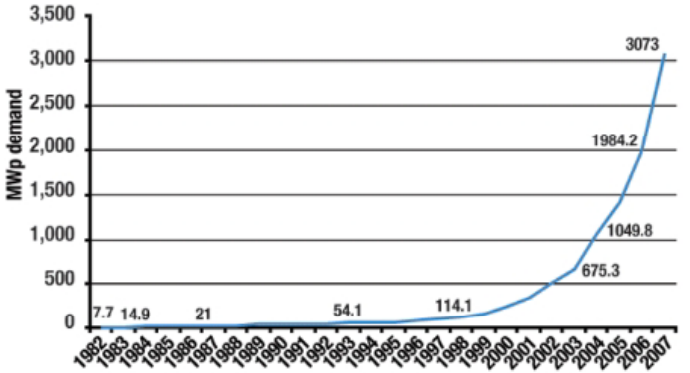
http://www.eeca.govt.nz/news/new-guidelines-help-bring-electric-vehicles-market

PHEVs Electric demand



Source: Bruce Smith (2009) "Electric Vehicles and generation development". NZ Electricity Commission.
Conference on :The Impact of Electric Vehicles on the NZ Electricity System

PVs Electric supply



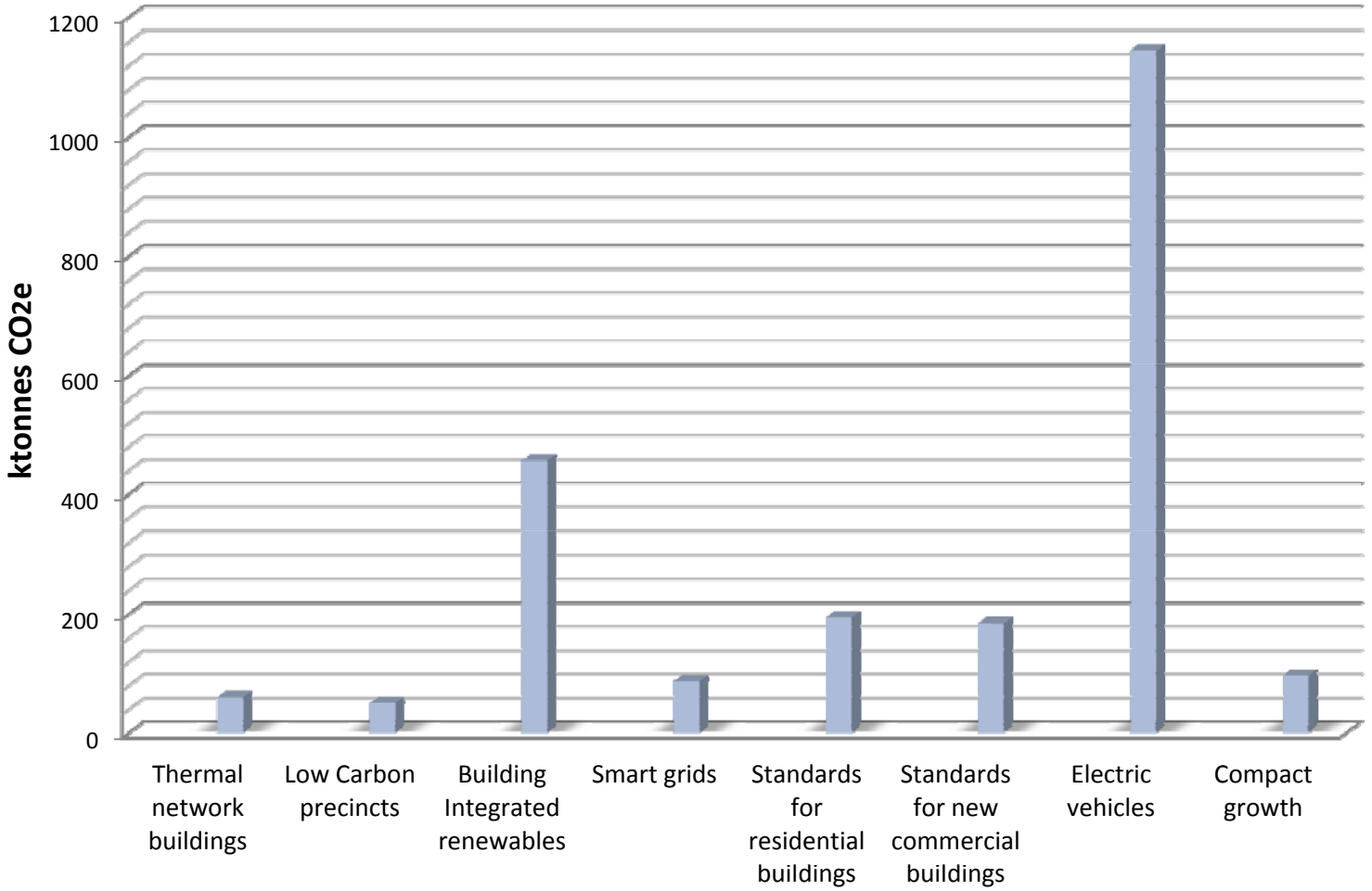
http://www.renewableenergyworld.com/rea/news/article/2009/08/the-pv-industry-2009-in-search-of-stability-and-sustainability1

Electric Vehicles: the basics

Electric vehicles in urban areas
4 x more efficient than petrol vehicles
3 x more efficient than hybrids

Disadvantages:
•Current range 100-150 Km (90% of NZ vehicles travel less than 69 Km per day in main urban areas)
•Cost ?
•Charging time: ½ hour to 7 hours
•Battery life

Advantages:
•NZ less oil dependent
•Health (noise & air pollution)
•Less CO_2 production



Potential Carbon Savings by 2031
In Auckland's built environment

ARUP (2011) Auckland Council Carbon Strategy, Technical Report

Case study: Auckland

What is the full potential of roof mounted photovoltaics for:

- Supply to a building
- Supply to the grid
- Charge electric vehicles (EVs)

Assumptions

1. Assumed that there is no subsidised Feed-in Tariff

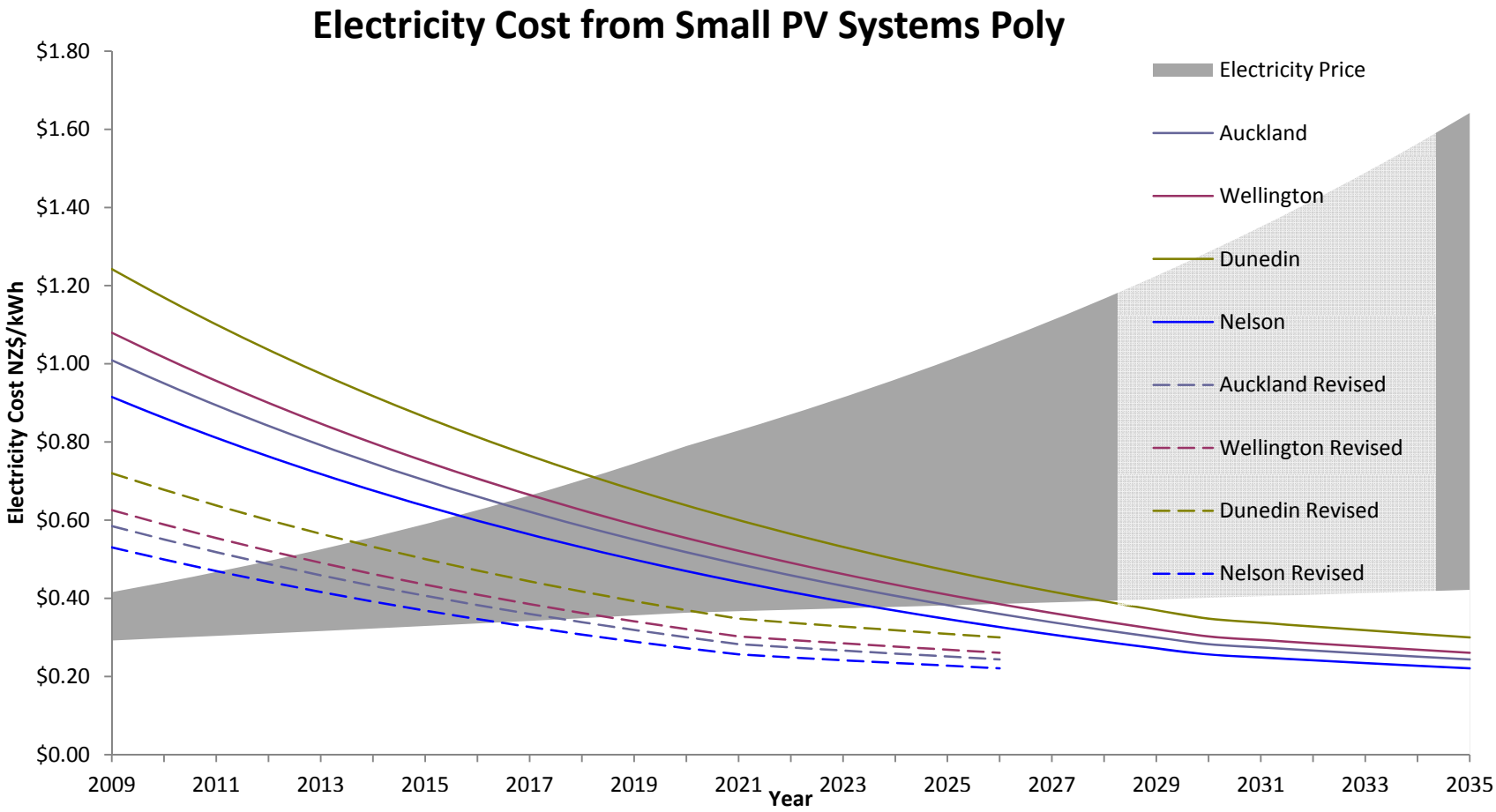
2. PVs are reducing in price and grid supply electricity is increasing in price making grid parity within the next decade.

3. Petrol prices will increase and electric vehicle (EVs) prices will decrease resulting in a general shift towards market penetration of EVs.

4. Smart meters with full functionality for feed-in and area networks

5. The research assumes the full market penetration of PVs in residential areas but various alternatives for PV ‘packages. 2kWp, 5kWp & 7+kWp

PV Energy Price Parity (Residential)



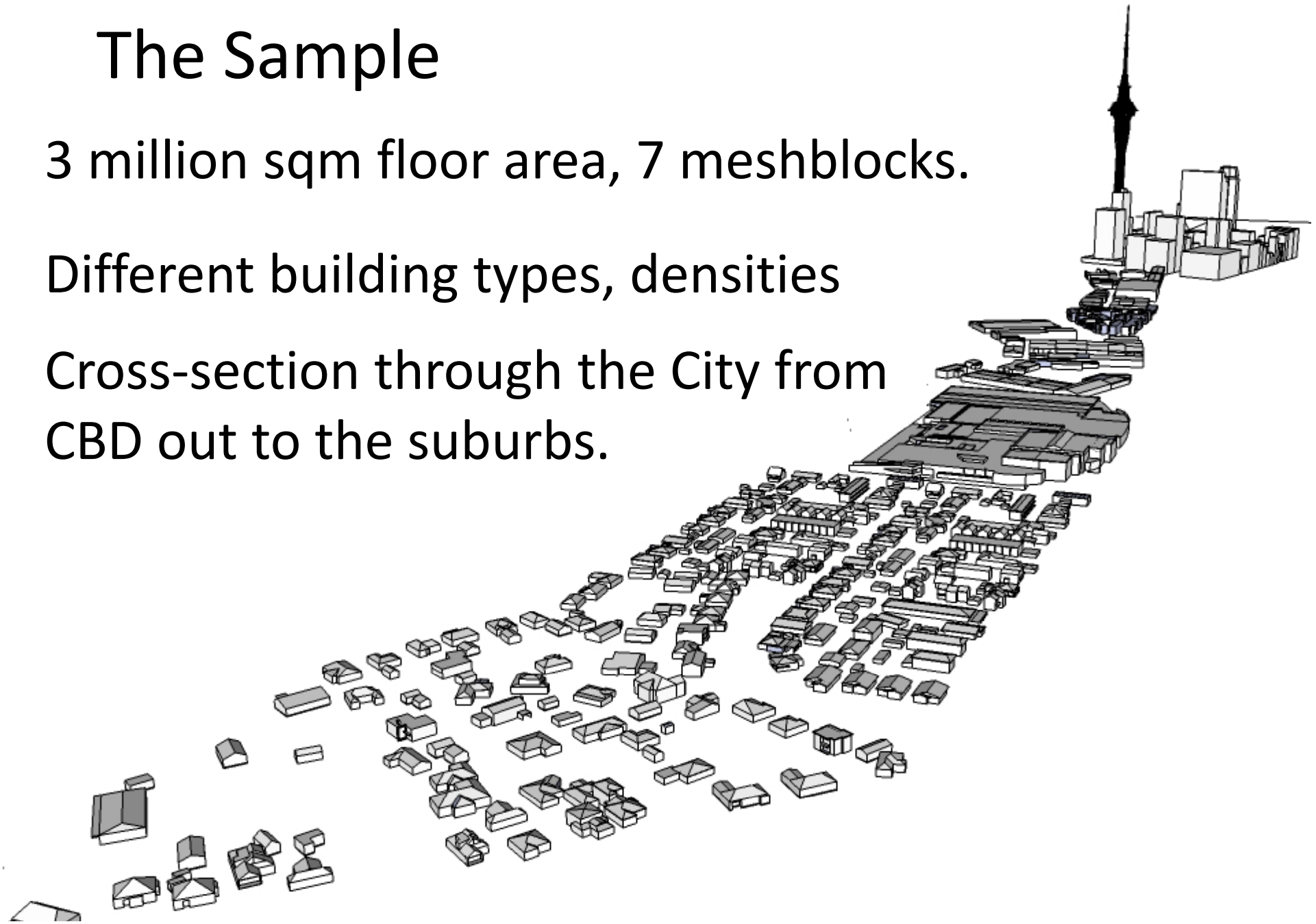
Source: IT Power Australia and Southern Perspective. (2009:70). *Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand*. Wellington: MED. *And EECA. (2012).* http://www.energywise.govt.nz/how-to-be-energy-efficient/generating-renewable-energy-at-home/solar-electricity-generation#costs

The Sample

3 million sqm floor area, 7 meshblocks.

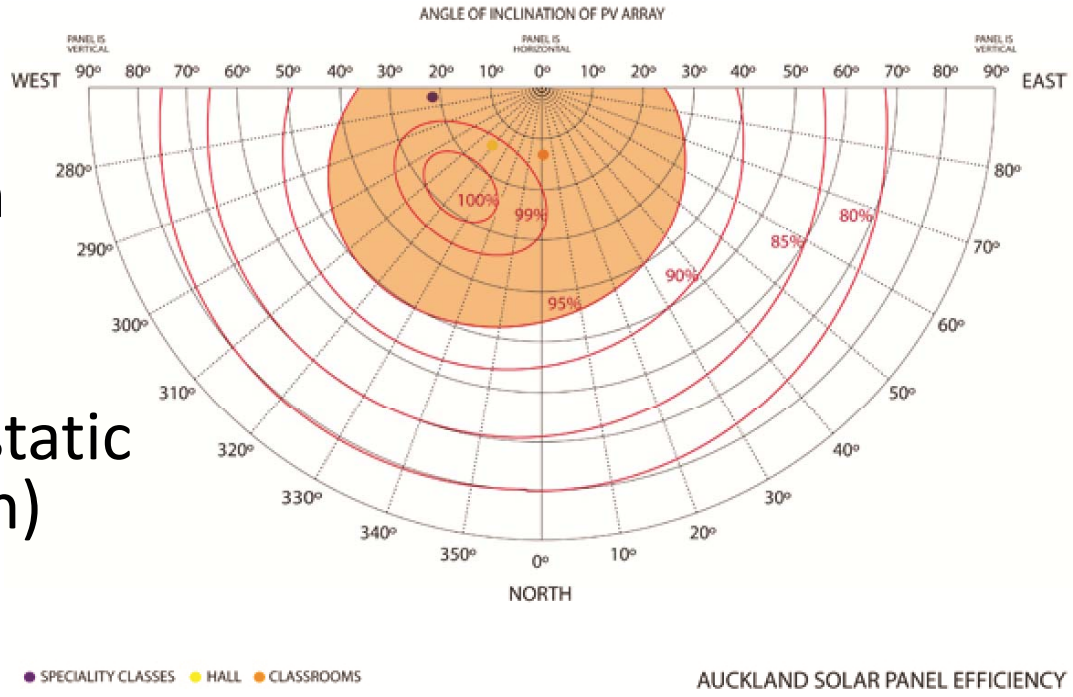
Different building types, densities

Cross-section through the City from CBD out to the suburbs.



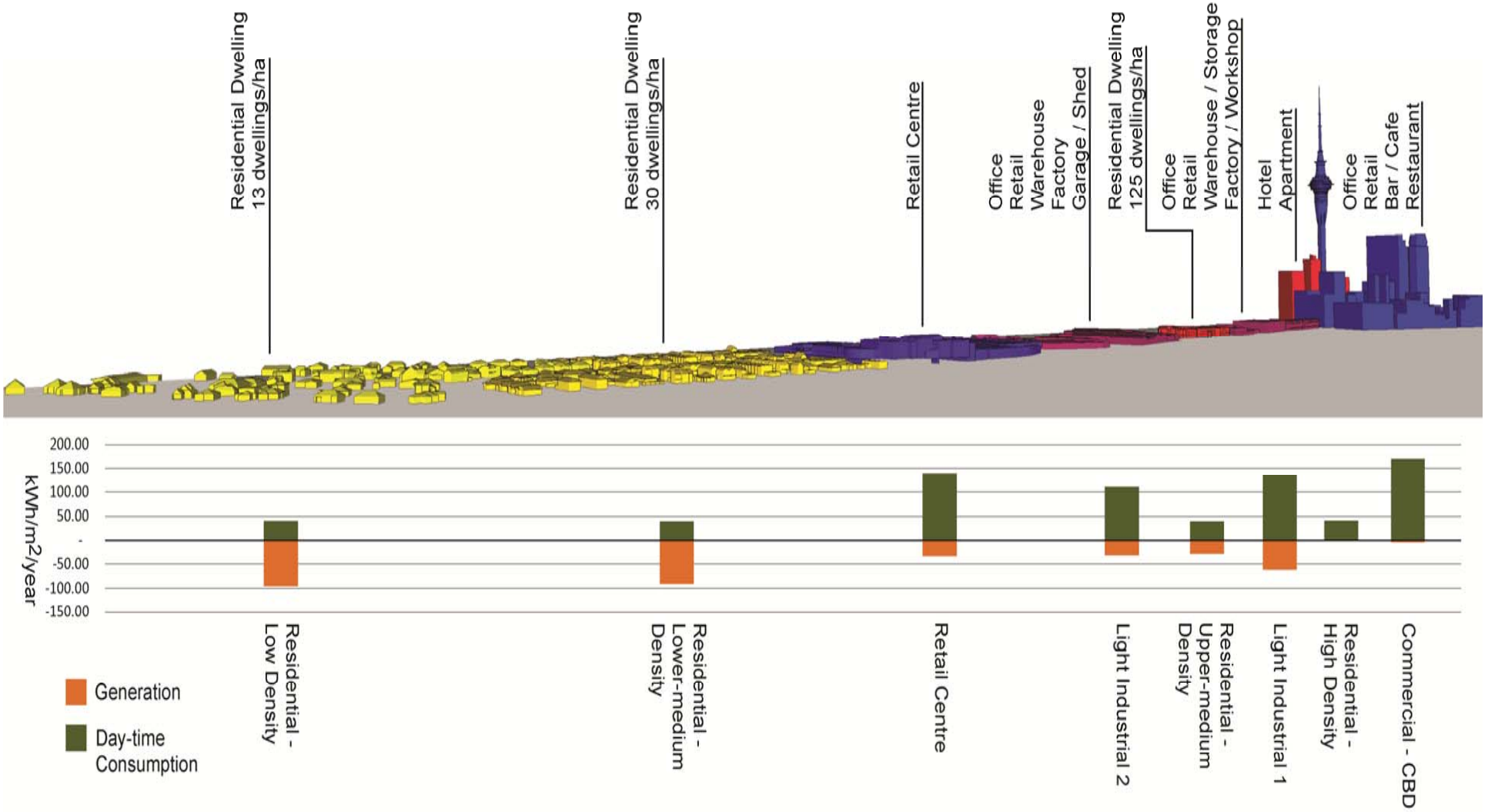
Technical Assumptions

- PVs limited to only the most efficient orientation and tilts of collectors.
- Only PVs mounted on buildings
- Assumed panels are static (not ‘tracking’ the sun)

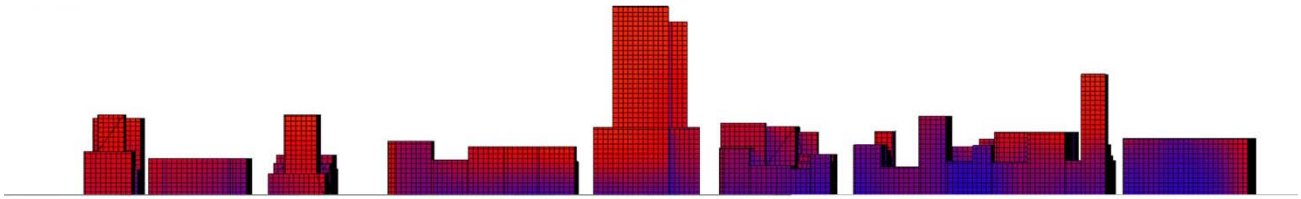


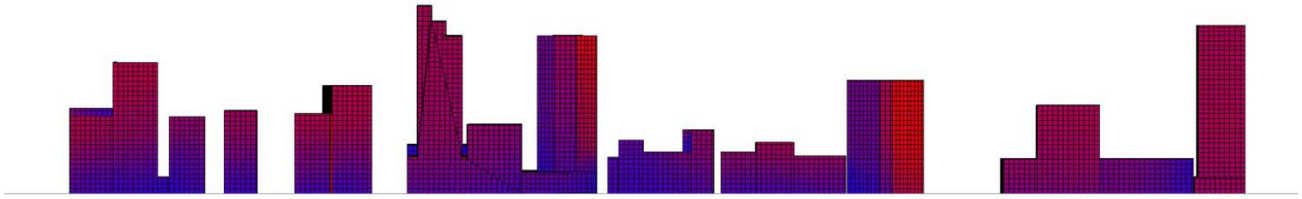
Sample Auckland

- Comparing the potential energy generated from PVs with the energy consumed by the building.

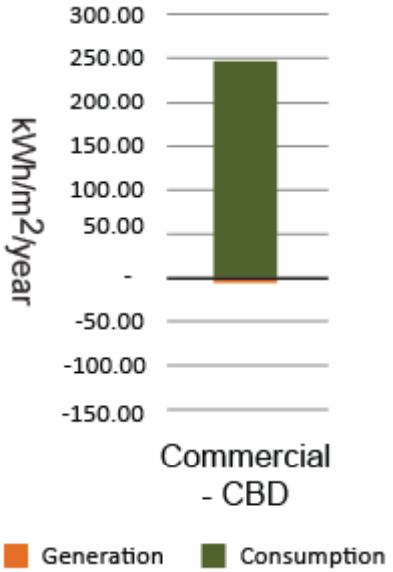


CBD Potential



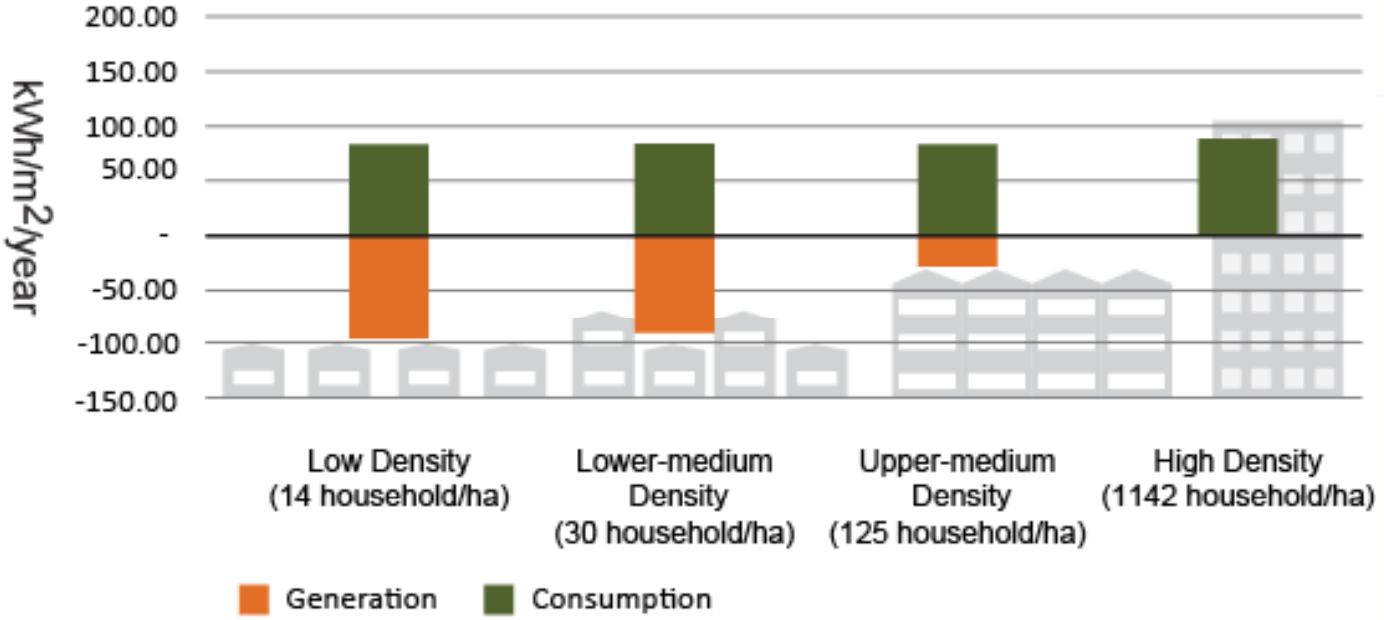


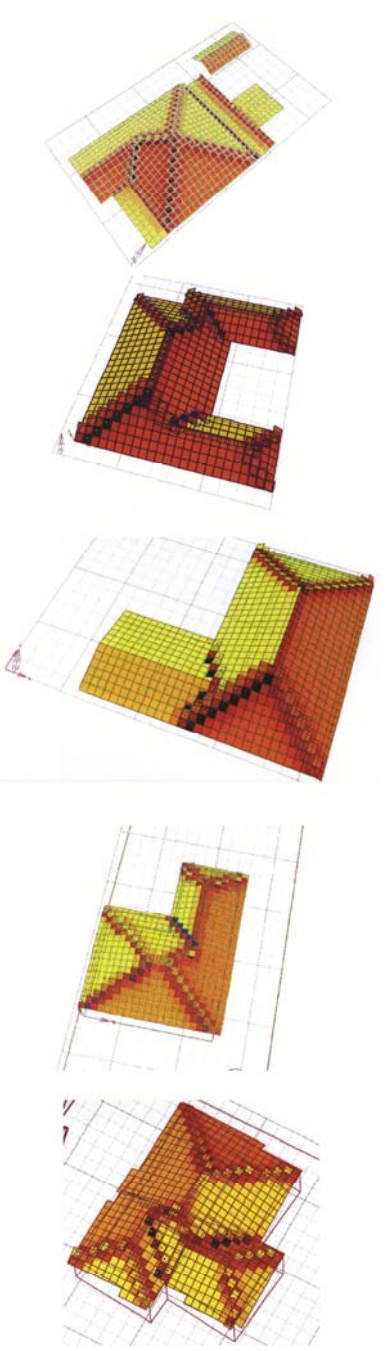
- Façade potential – Low
- Roof potential – Restricted by area & over-shadowing
- Consumption - High



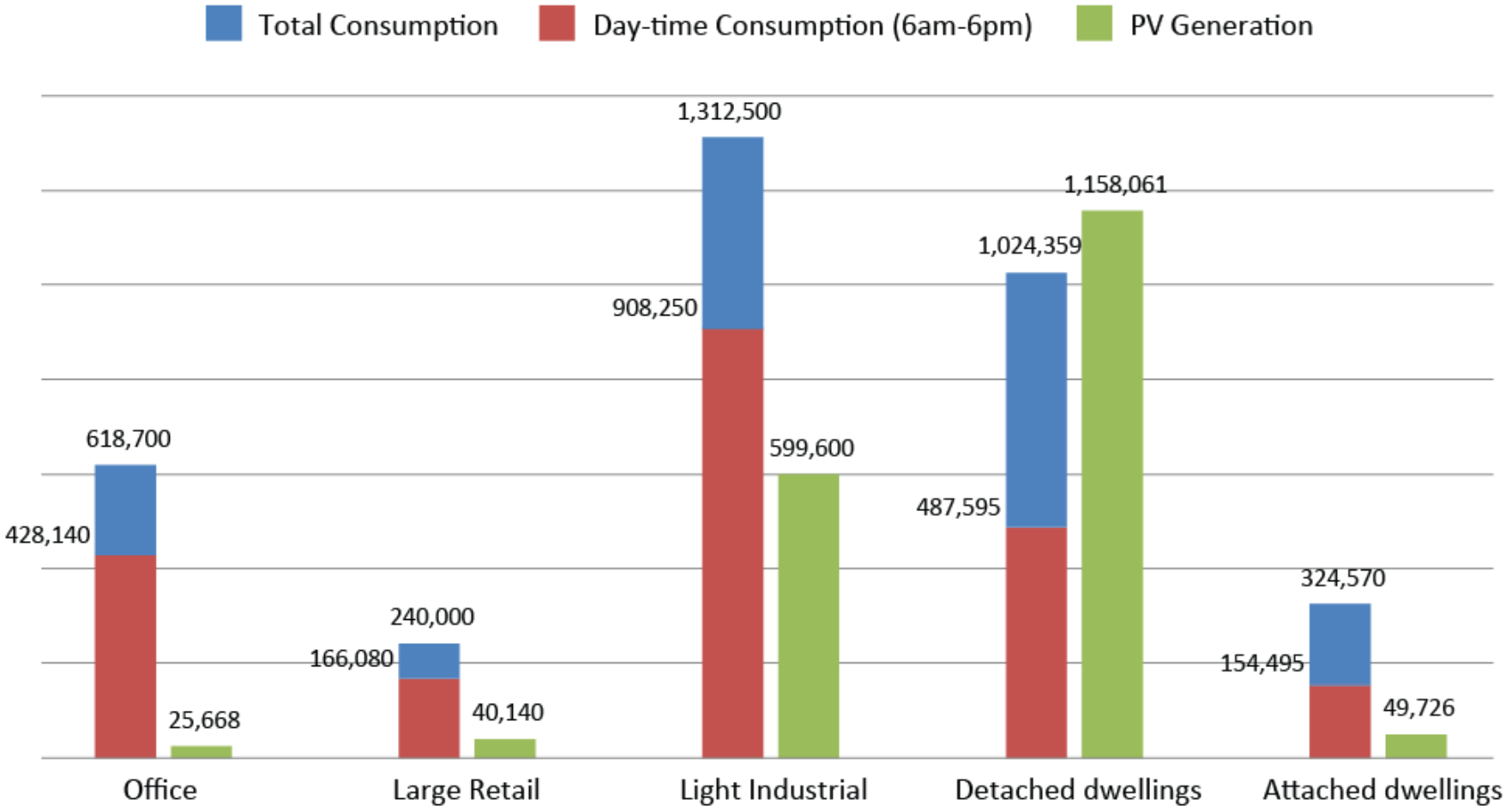
Residential Potential

- Low Density – High Solar Potential
- High Density – Low Solar Potential



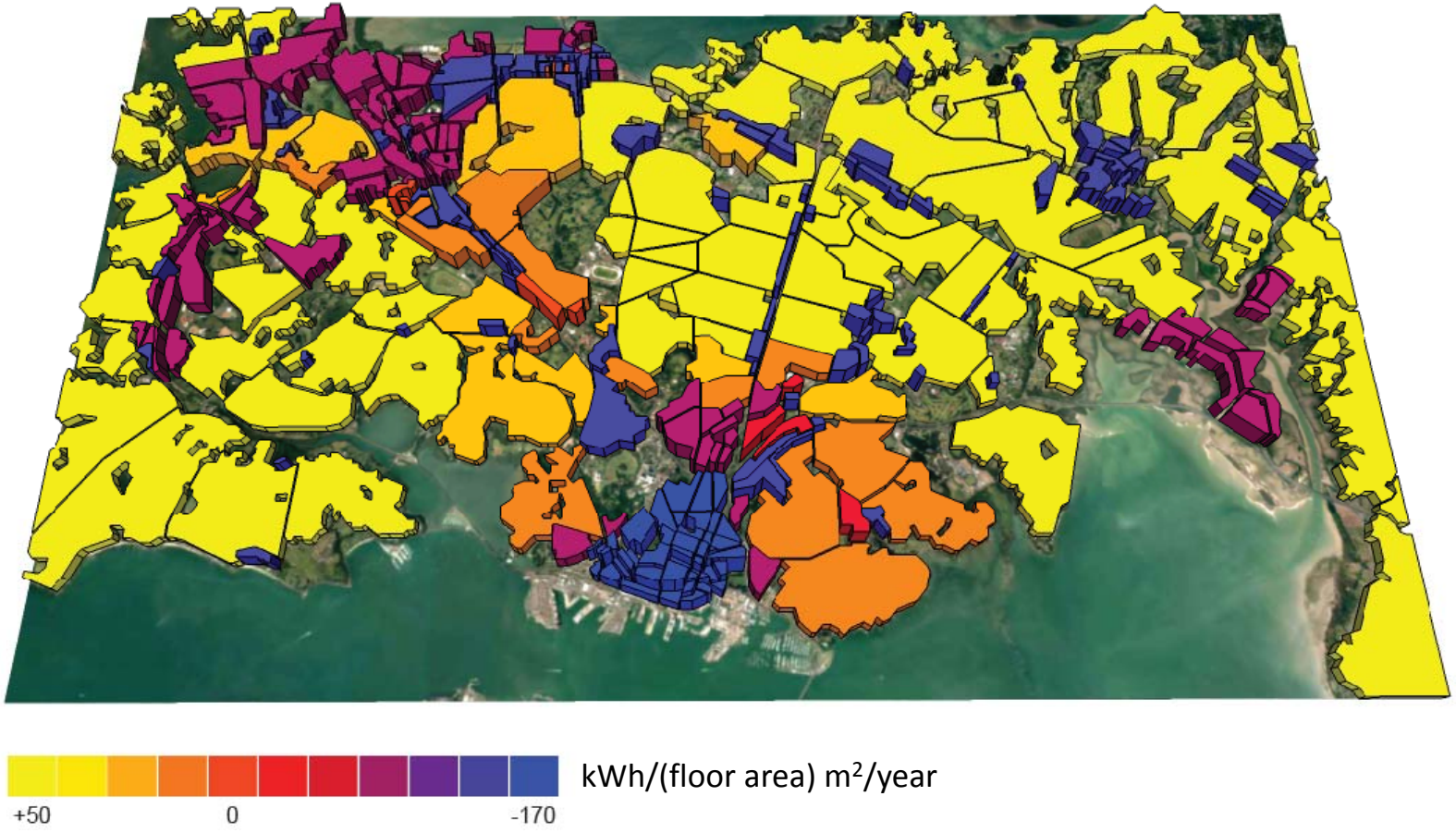


Annual Energy Consumption & Maximum Generation by PV (GWh/year) Extrapolated for the whole City



Solar Energy Net-metering Potential

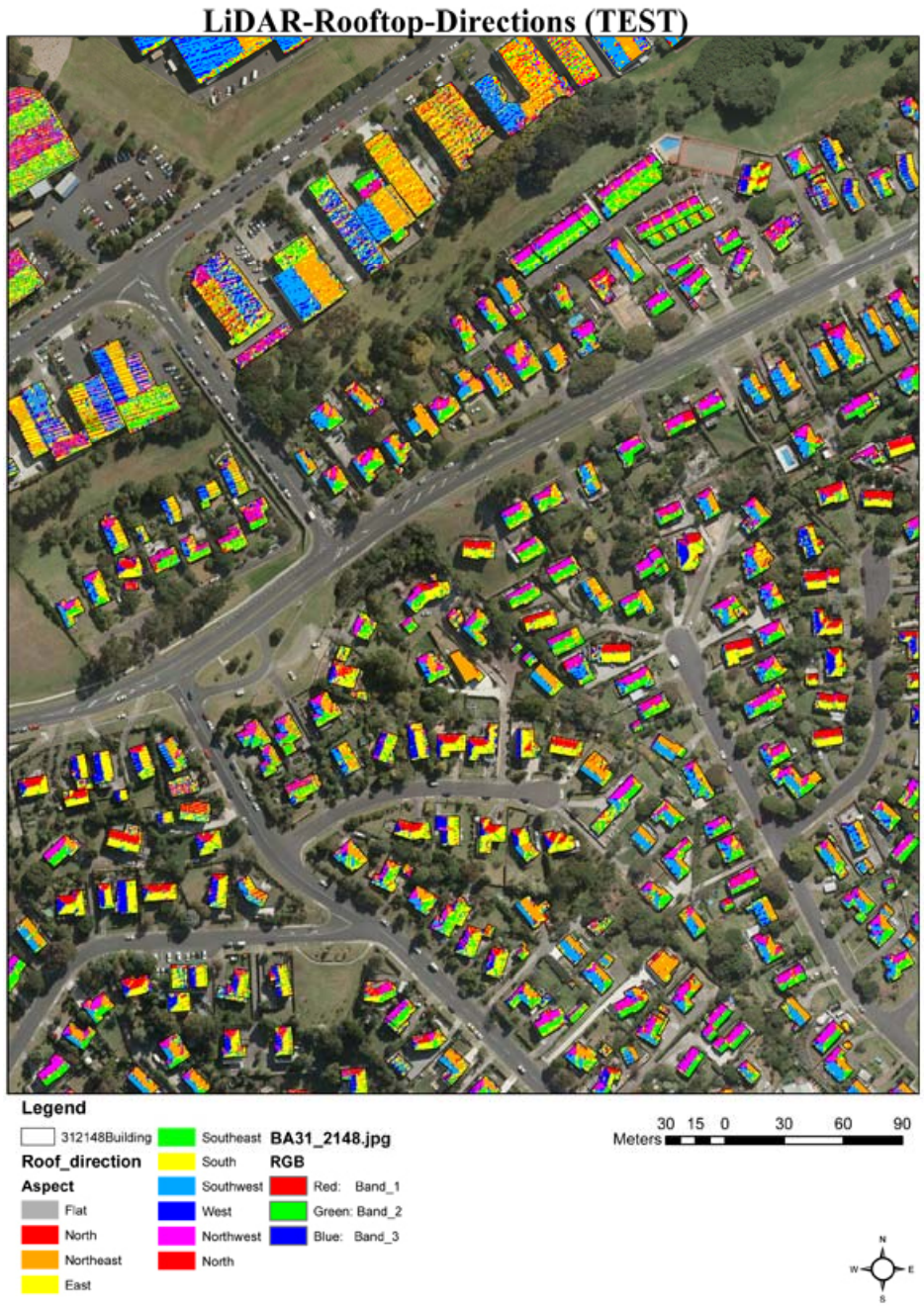
- Residential suburbia has high net-metering potential while industrial buildings can benefit directly from their own generation.



LIDAR

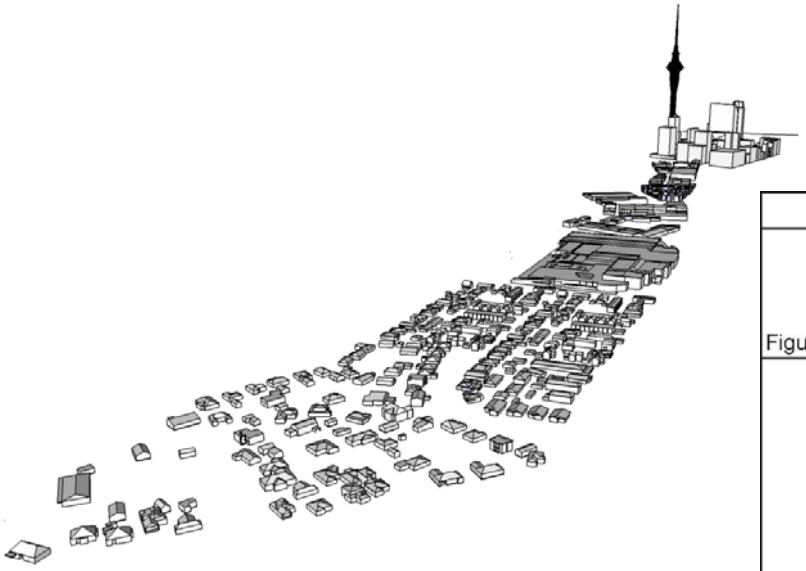
(Light Detection And Ranging)

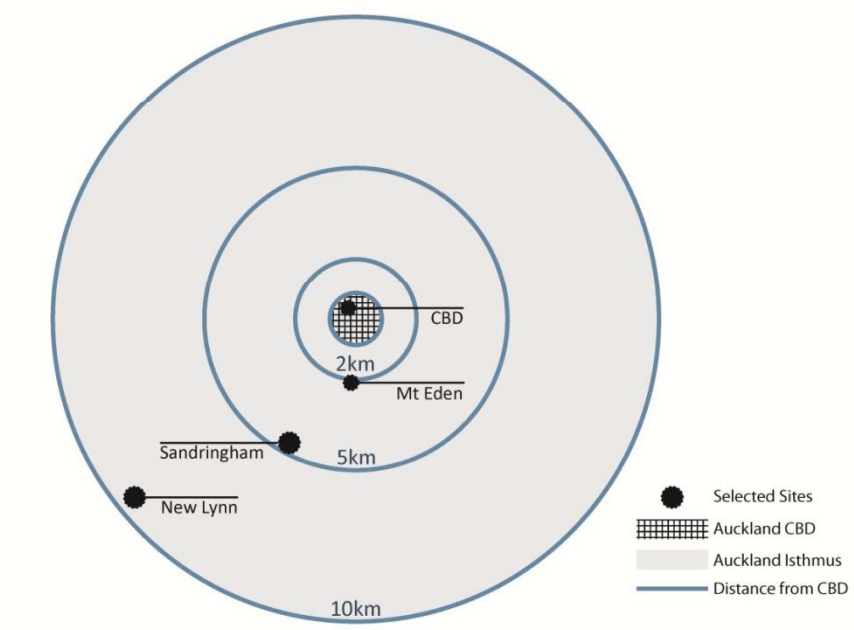
- Allows quick analysis at a larger scale

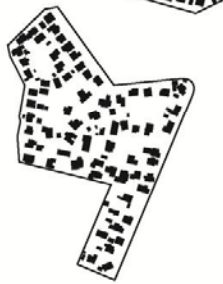


Transport Energy

Density and distance





Population Density on Selected Residential Blocks				
Figure not to scale	Site Name	Population Density 1 (households/ hectare)	Population Density 2 (persons/ hectare)	Residents per Household
	CBD	1142.2	2198.3	1.9
	Mt Eden	125.3	321.5	2.6
	Sandringham	29.9	104.2	3.5
	New Lynn	13.5	47.1	3.5

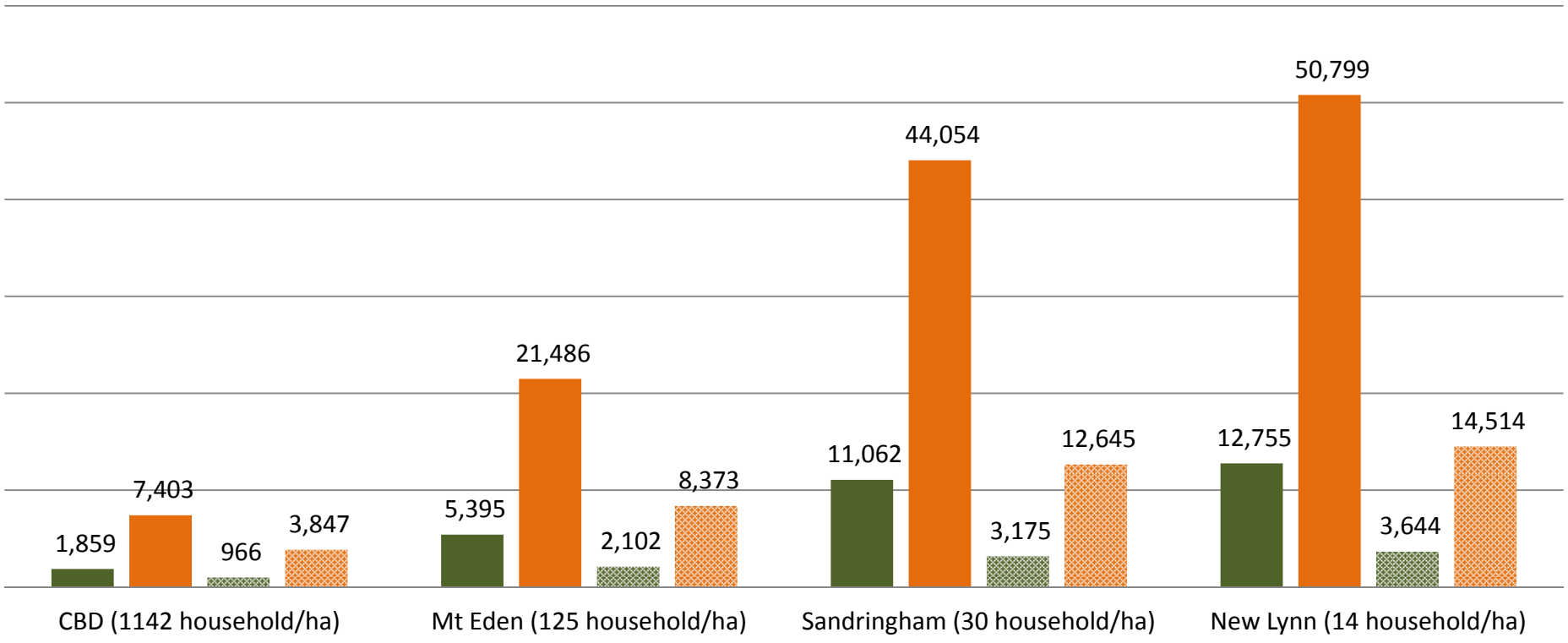
Travel distance and energy consumption

Daily Average Travel Distance per Vehicle Drivers (km)					
Purpose	Major Urban Areas	High Density Site	Upper-medium Density Site	Lower-medium Density Site	Low Density Site
Home	6.4	6.4	6.4	6.4	6.4
Work - main job	4.3	2.5	2.5	5.0	8.0
Work - other job	0.1	0.1	0.1	0.1	0.1
Work - employer's business	0.8	0.8	0.8	0.8	0.8
Education	0.2	0.2	0.2	0.2	0.2
Shopping	1.9	1.9	1.9	1.9	1.9
Personal business/ services	1.1	1.1	1.1	1.1	1.1
Medical/ dental	0.2	0.2	0.2	0.2	0.2
Social visits	2.2	2.2	2.2	2.2	2.2
Recreational	1.0	1.0	1.0	1.0	1.0
Change mode	0.3	0.3	0.3	0.3	0.3
Accompany someone else	1.1	1.1	1.1	1.1	1.1
Total	19.4	17.8	17.8	20.3	23.3

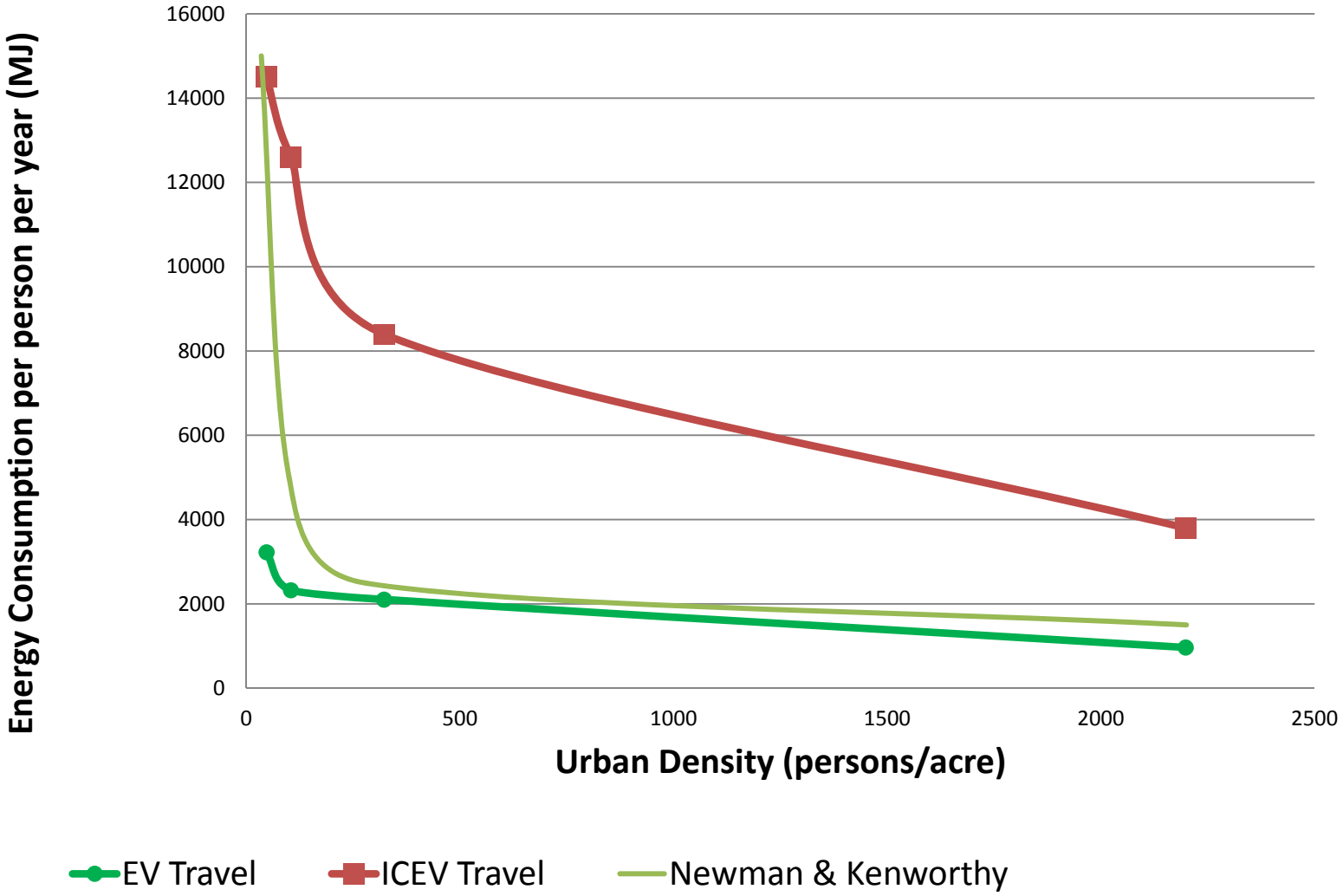
Abley, S. Chou, M. and Douglass, M. (2008) *National Travel Profiles Part A: Description of Daily Travel Patterns* (NZ Transport Agency Report 353). Wellington: NZ Transport Agency. And Census 2006.

Residential block	Distance travelled per person per year (km)	Petrol Consumption per person per year in Litres (L) at rate 0.10L/km*	Diesel Consumption per person per year in Litres (L) at rate 0.09L/km*	Electricity Consumption per person per year (kWh) at rate 0.243 kWh/km**
CBD Apartments	1,104	101	9	268
Mt Eden	2,404	219	19	584
Sandringham	3,631	330	29	646
New Lynn	4,167	379	34	896

Travel Consumption Comparison

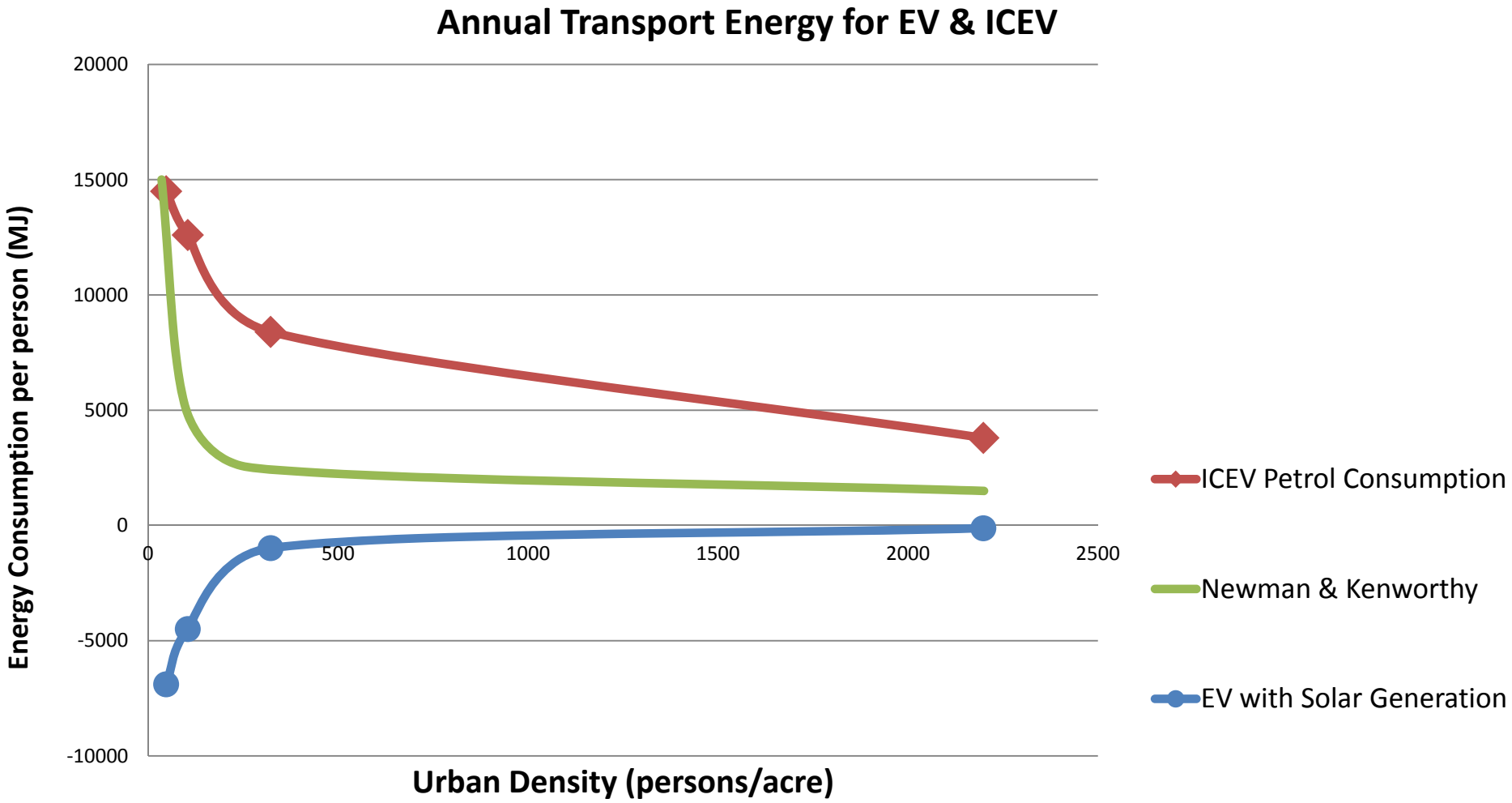


EV & ICEV travel energy consumption in Auckland



PV Generation for EV use

- EV with Solar PV ‘reverse the curve’



Where to go from here…

- Travel behaviour adaptation/change with EVs?
- Only 20% of travel distance is for commuting: leave car at home to charge during the day?
- EV & PV synergy encourages public transport for commuting?
- Combined sale of EVs and PVs ?
- Renting roofs?

Daily Domestic Demand vs PV Supply

- 5kWp PV system – typical electricity generation profile
-